Homework II

Problem 1

Write a one paragraph proposal for what you would like to do your final project on. We will give feedback on it, so you can use it as an opportunity to check whether any project ideas you may have are appropriate/acceptable. Don't worry about committing to an idea so early; it is okay to change your project topic later. Some project guidelines are given below. There are three options: (1) a literature review on a topic related to cell mechanics and/or mechanotransduction, (2) a review of a topic on cell mechanics that was not covered in class, or (3) an analysis of some mechanical phenomenon related to cell mechanics. Papers in the past have generally been about 5-10 pages, double spaced, with figures and references. Some examples of what students have written about are:

- Fluid Shear-Induced Deformation of a Segment of Viscoelastic Cell Membrane
- Scanning Near-Field Optical Microscope Nanopipette: A New Method for Cell Mechanics
- Mechanotransduction of Touch Cells in C. Elegans
- Force of Interaction in Lipids
- Shear-Induced Production of Nitric Oxide and its Effect on Smooth Muscle Cells

Problem 2

We saw that the entropic spring constant for a Gaussian chain in three dimensions is $(3kT)/(Nb^2)$, where k is the Boltzmann constant, T is the temperature, N is the number of segments, and b is the segment length. Imagine an experiment in which the polymers motions are constrained to only two dimensions (for example, by sandwiching the polymer between two pieces of glass that are separated by a distance that is slightly bigger than the polymer diameter).

- Derive the 2D probability distribution of the end-to-end vector $\mathbf{R}$ of the Gaussian chain, $P_{2d}(N, \mathbf{R})$.
- Using the above result, derive the entropic spring constant in two dimensions. What happens to the spring constant by constraining the motions to two dimensions?

Problem 3

In class, we briefly saw that the persistence length l_p of a Gaussian chain with segment length b is $2l_p = b$. In this problem, we see where this expression comes from. It can be shown that for a worm-like chain with persistence length l_p and contour length L, its average squared end-to-end distance is $\langle \mathbf{R}^2 \rangle = 2l_p^2(\exp(-\frac{L}{l_p}) - 1 + \frac{L}{l_p})$ (see Howard, page 112).

- What is the $\langle \mathbf{R}^2 \rangle$ for the worm-like chain in the limit of very long contour length, $L >> L_p$?
- What is the $\langle \mathbf{R}^2 \rangle$ for the Gaussian chain?
- Thus, in the limit of $L >> L_p$, what is the effective persistence length of the Gaussian chain, if we model it as a continuous worm-like chain?
- Knowing that the persistence length gives a characteristic length scale at which the orientations of the ends of a polymer segment become uncorrelated, why does this make sense?